A NEW FAMILY, GENUS, AND SPECIES OF SCALE INSECT (HEMIPTERA: COCCINEA: KUKASPIDIDAE, NEW FAMILY) FROM CRETACEOUS ALASKAN AMBER

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Abstract.—A new genus and species of scale insect, ***Kukaspis usingeri*** is described from Cretaceous Alaskan amber and placed in a new extinct family, the **Kukaspididae**. This fossil is a derived member of the superfamily Orthezioidea, with six pairs of unicorneal eyes forming lateral rows, a scutum with a large subrectangular membrane, a tubular scutellum separated from the mesopostnotum by a large membrane, wings narrow with a clear posterior (claval) flexing line, but a reduced anterior one, narrow parallel-sided halteres; a unique waxy tail consisting of four soft filaments arising from the last abdominal tergite and a penial sheath divided into basal capsule and stylus with a hook-like apex. Relationships of this peculiar Lower Cretaceous form with both extant and extinct forms are discussed.

Key Words: fossil scale, Hemiptera, Orthezioidea, Coccinea, *Kukaspis usingeri,* Cretaceous Alaskan amber

Alaskan amber is perhaps the most intriguing and least known of the Cretaceous fossiliferous ambers. Its outcrops between the Brooks Range and northern coastline comprising the Arctic Coastal Plain and Foothills were discovered and explored by R. Usinger and R. Smith (see Poinar 1992 for further discussion and early exploration of the Alaskan amber deposits). While there was originally some question whether the amber deposits originated from the Upper or Lower Cretaceous, the most recent study places the Kuk deposits as Late to Middle Albian (97–104 million years) (Scott and Smiley 1979). Chemical analysis of the amber indicates that the plant source was a member of the Araucariaceae, probably *Agathis* (Lambert et al. 1990).

The coccid male described in this paper is only the second description of an organism in Alaskan amber, the first being a ceraphronid wasp, the present whereabouts of which is unknown (Muesebeck 1963). Some insect groups from Alaskan amber were mentioned in the reports of Hurd et al.(1958), namely empidid flies, an eulophid wasp and an adelgid, and Langenheim et al. (1960) reported ceratopogonid and empidid flies and an eulophid and ceraphronid wasp (the latter fossil presumably the one later described by Muesebeck 1963).

Studies on Cretaceous scale insects were initiated by Beardsley (1969) on Upper Cretaceous Canadian (Cedar Lake) amber. Further Upper Cretaceous coccids have been described from Siberian (Taimyrian) (Koteja 1989a) and New Jersey amber (Koteja 2000). Lower Cretaceous impressions have been found in Siberia and southern England (Koteja 1988, 1989b, 1999). Undescribed scales also occur in Cretaceous Lebanese, Canadian, and Burmese amber (Schlee 1972; Poinar 1992, 1998; Pike 1994; Rasnitsyn 1996; D. Azar, D. Grimaldi, A. Ross, personal communications), thus scale insects appear to be quite abundant in Cretaceous deposits.

The present study deals with a coccid male found in Alaskan amber, first published by Poinar (1998), as a "male scale insect." The specimen appears to be a peculiar archeococcid (Orthezioidea), but with some derived features characteristic of neococcids (Coccoidea). The combination of characters exhibited by the male does not fit any established group, thus a new extinct family is created to contain it.

Material and Methods

The present fossil was collected by R. Usinger and R. Smith from Cretaceous outcrops on the West side of Kuk Inlet at Pugnik Beach, in 1955, which occurs between Brooks Range and the northern Alaskan coastline.

The amber piece is flat, ca. 9 mm long by 8 mm wide, transparent, yellowish brown with a dark brown film separating subsequent resin flows which is also characteristic of Canadian and Lebanese amber. Except for the coccid, no other organic or inorganic inclusions are in the piece. At the present state of preparation, the inclusion can be observed only from its right side and many structural details are difficult to see because of the thick layer of resin overlying the specimen, however further polishing could damage the specimen. The inclusion is well preserved and not obscured by impurities or bubbles. The dark color of the specimen makes observation difficult and some details cannot be seen despite the use of high light intensity. Sclerotized and membranous body parts can clearly be distinguished, the former being black and the latter silver in direct light. Ordinary light microscopes were used to examine and draw the inclusion. The thick layer of resin limited the use of objectives higher than 16× (ca. 160× combined magnification). Descriptive terms for the males as well as other morphological details were taken from Theron (1958).

Kukaspididae Koteja and Poinar, new family

Type genus.—*Kukaspis*, new genus.

Etymology.—The family name refers to the Kuk Inlet in which the amber was found.

Description.—Archeococcids (Orthezioidea) with dinintegrated compound eyes; single ommatidia forming oblique lateral rows; spherical pedicel; cylindrical flagellar segments bearing short setae; scutum with large subrectangular membrane; scutellum short, tubular; wings membranous, subcostal and cubital ridges weak, anterior flexing line reduced, posterior one present; halters narrow; all trochanters with numerous setae; abdomen with four soft waxy filaments arising from last tergite; penial sheath formed of basal capsule and stylus with hooked apex; aedaegus sickle-like, acute; structure of tail organs unique in scale insects; with an apically hooked penial sheath which is shared with the Putoidae.

Kukaspis Koteja and Poinar, new genus

Type species.—*Kukaspis usingeri*, new species.

Description.—Archeococcid (Orthezioidea) with a circle of 10–12 unicorneal eyes; pedicel short, cylindrical flagellar segments, antennal setae short, capitate setae absent; scutum oval, large rectangular scutal membrane very short, tubular scutellum with an oval foramen; mesopostnotum separated from scutellum by large membrane; wings elongate-oval, finely sculptured; microtrichia absent; subcostal and cubital ridges weak with only posterior (claval) flexing membrane developed; halters narrow, with 2 setae; legs short, all trochanters with numerous setae, tarsal and ungual digitules capitate; tail organs consisting of four soft waxy filaments arising from last abdominal tergite; penial sheath with a globose basal capsule and stylus, latter with a hook-like extension dorsally; aedaegus acute, extending beyond apex of penial sheath.

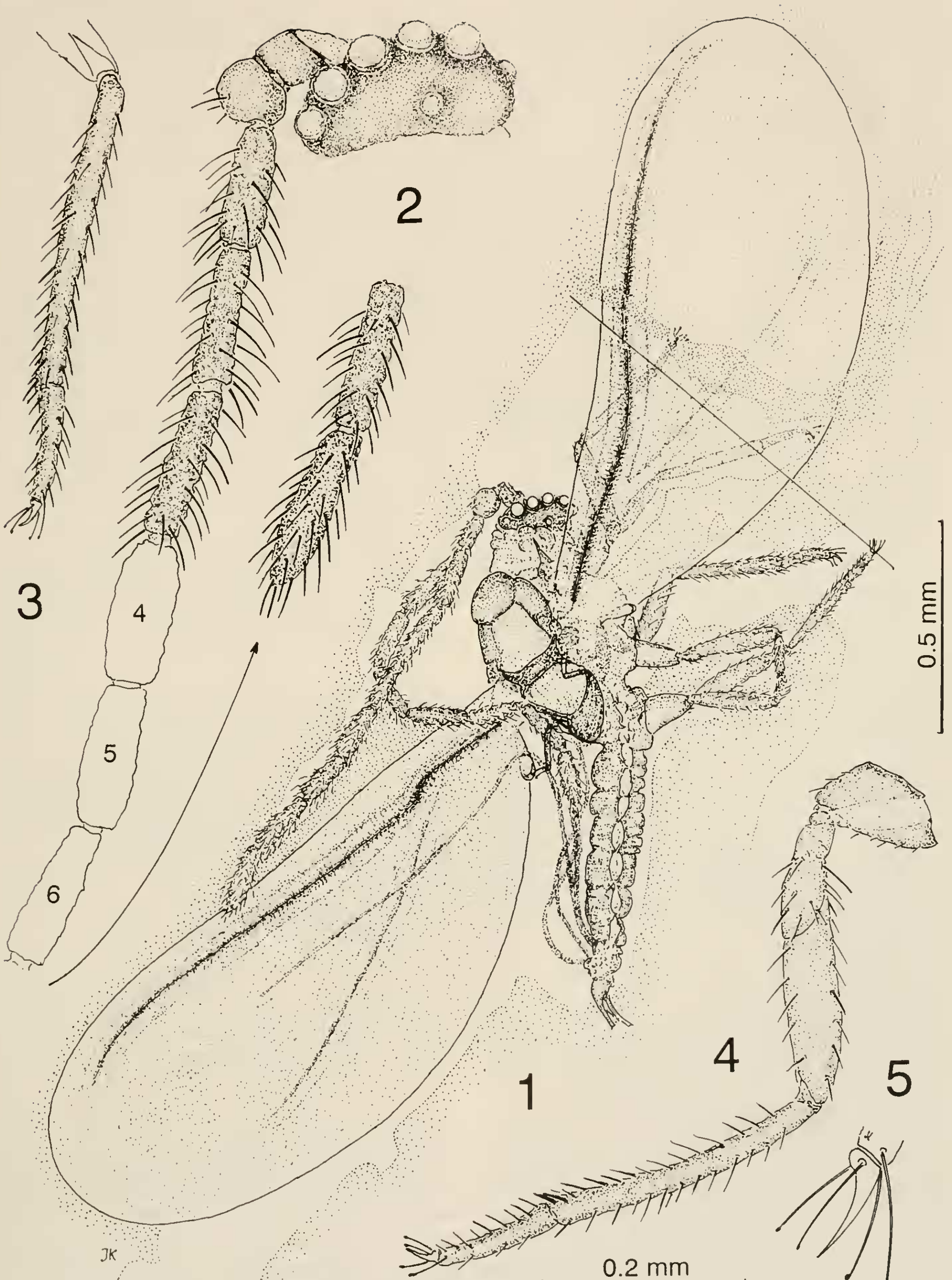
Etymology.—The generic name refers to The Kuk river, Alaska.

Kukaspis usingeri Koteja and Poinar, new species
(Figs. 1–9)

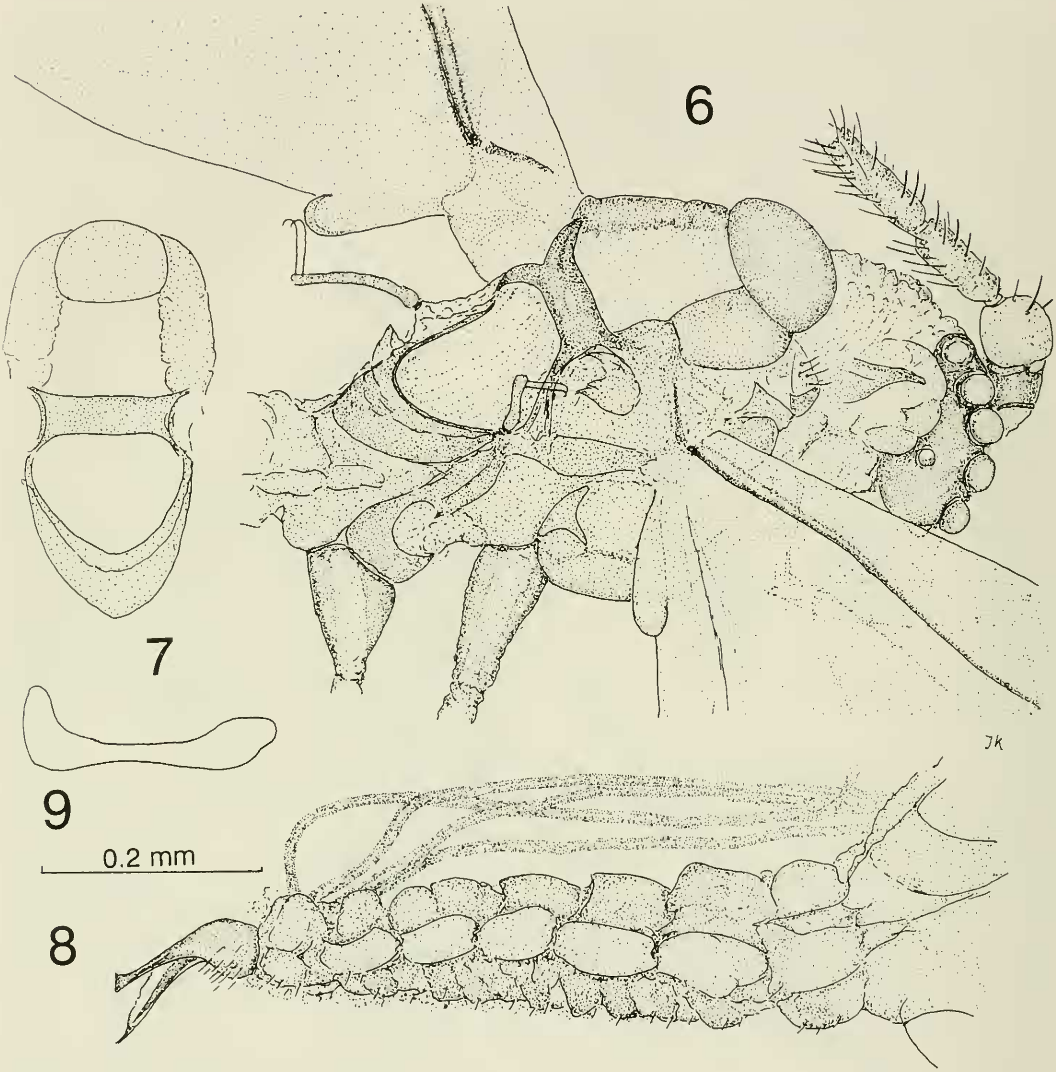
Holotype.—Alate male Cocc-876 inclusion in Alaskan amber, deposited in the collection of G. Poinar (HO-4-30) maintained at Oregon State University, Lower Cretaceous, Kuk Inlet at Pugnik Beach between Brooks Range and the northern Alaskan coastline.

Etymology.—The species is named in honor of Dr. Robert Usinger, one of the first to realize the scientific value of Alaskan amber.

Description.—Only holotype available; accessible from right side, but some dorsal and ventral structures also can be examined. Sclerotized body parts dark brown. Body 1.32 mm long; wing expanse 3.20 mm; head 120 μm long, 180 μm high, with strong ocular sclerites bearing 6 (possibly only 5) pairs of simple (unicorneal) eyes in oblique lateral rows and a pair of ocelli; dorsum of head seems completely membranous; a few short setae recognizable at outline of head; antenna filiform, 10-segmented, 1,170 μm long, slightly shorter than body; scape difficult to define; pedicel globose, 65 μm in diameter; flagellar segments cylindrical, ca 35 μm wide (some flattened after preservation), terminal segment with acute apex; first flagellar segment 90 μm, others 140–160 μm long, apical segment longest; all segments bearing numerous setae about as long as segment width, including hair-like and thick setae; antennal bristles recognized at terminal segments but number and position difficult to ascertain; capitate setae apparently absent; other types of sensilla not recognized. Thorax 510 μm long, 360 μm deep. Prothorax with large bulged post-tergites; scutum perhaps oval, medial membrane very large, subrectangular; scutellum cylindrical, subrectangular in dorsal view, very short (40 μm), with an oval foramen; mesopostnotum well developed, separated from scutellum by a large membrane, overlapped with a metathoracic fold; mesosternum strongly bulging; a few short setae noted on various parts of thorax. Legs (in oblique positions on drawing) relatively short, 890 μm long, slender; coxae 110 μm; trochanters+femora 300 μm, tibiae 280 μm, tarsi 110 μm, claws 30 μm; all segments (including trochanter) with numerous short straight setae, some spine-like; tibiae with few apical spurs; claw narrow but with broad base, without denticles; tarsal and ungual digitules knobbed, 35 μm and 25 μm respectively. Wings 1,500 μm long, 600 μm wide, with fine granulate sculpture; presence of microtrichia problematical, not recognized on wing margin where usually best visible; subcostal and cubital ridges weakly sclerotized; anterior flexing line absent, posterior (claval) one distinct and represented by a membranous patch which does not reach wing margin (an associated trachea visible on right wing); pouch for holding halteral setae elongate, strongly sclerotized; basal alar setae and cupolae along subcostal ridge present, difficult to count. Haltere narrow, parallel sided, 120 μm long, bearing 2 setae. Abdomen cylindrical (compressed as shown on Fig. 9), 695 μm long, with well developed tergal and sternal sclerites, short setae and wax glands (secretions forming a granulate coating). Tail organs peculiar, consisting of four flexible filaments (tubes?) protruding from last abdominal tergite; each apparently secreted by a single multilocular gland; particular threads arising from single loculi intertwined and forming a rope, perhaps as long as body. Penial sheath (in lateral view) consisting of distinct capsule and stylus, both 120 μm long, capsule 35 μm high; stylus with peculiar hooked apex (as



Figs 1–5. *Kukaspis usingeri*, holotype. 1, Outline of body in laterodorsal view (note one of the waxy tails above the left wing). 2, Right ocular sclerite and antenna (segments 4 and 5 compressed). 3, Mid tibia and tarsus. 4, Foreleg. 5, Apex of tarsus.



Figs 6–9. *Kukaspis usingeri*, holotype. 6, Head (lateral) and thorax (laterodorsal). 7, Reconstruction of mesothorax (dorsal; note the metathoracic fold above mesopostnotum). 8, Abdomen (lateral); note four waxy tails bent headward. 9, Optical cross-section of abdomen showing dorsoventral compression.

in *Puto*); a group of setae on ventral face of capsule, sensilla on stylus not noted. Aedaegus acute, with a slit-like dorsal gonopore projecting beyond apex of penial sheath.

Discussion

Scale insects are believed to have split into two groups at an early stage of their radiation: the archeococcids (Orthezioidea) and neococcids (Coccoidea). The former bear several plesiomorphic features, such as abdominal spiracles and compound eyes, but developed also specialized structures and behaviors sometimes paralleling those of the neococcids, both in extant and fossil faunas (Koteja 2000). The neococcids are descendants of the Putoidae (Koteja 1996) and are monophyletic; the ancestor of the archeococcids is unknown and their monophyly is not evident. Studying the phylogeny of scale insects and relationships of particular groups based on fossil material presents two problems: some essential microscopic structures are not discernable (e.g., abdominal spiracles) and some specialized convergent features occur in both archeo- and neococcids, thus the assignment of fossil forms to one of these branches can be difficult. At first glance, the Alaskan amber male resembles a neococcid, with tubular (rectangular in dorsal view) scutellum, large rectangular medial scutal membrane, well developed capitate tarsal and ungual digitules, reduced "venation" of forewing, disintegrated compound eyes, four waxy tails and other characters. However, a detailed analysis of these features indicates that this species (family) must be a derived member of the archeococcids.

In scale insects, the prothorax is largely membranous, with minute paired pronotal and post-tergal sclerites in some groups, the largest in the digging Margarodidae. In inclusions, the prothorax is significantly shrunken, almost non-existent, and the mesothoracic prescutum seems to be attached to the head. In *K. usingeri,* there are conspicuous bulged sclerites on each side of the prothorax comparable in size with those in the margarodids, however, the anterior legs are of normal walking (not digging) structure.

A short broad tubular scutellum, often with a foramen, is characteristic of advanced neococcids (Coccidae, Diaspididae and others); however, it has been found also in the Steingeliidae and Electrococcidae among the aberrant archeococcids (Theron 1958, Koteja 2000). In neococcids, the trochanter bears a few setae only (perhaps a maximum of 10 in *Puto*), usually with a distinct long apical seta. In archeococcids there are numerous subequal setae on this joint. The conditions in *K. usingeri* correspond with those in archeococcids.

The wing skeleton (subcostal and cubital ridges) is simple and weak in *K. usingeri,* as in the neococcids and some specialized archeococcids, but there is a distinct claval flexing line, never encountered in the neococcids, but present in the archeococcids. Neococcid wings bear microtrichia, developed also to some extent in fossil archeococcids (Koteja 1996). Although microtrichia have not been observed on the wing margin (usually best visible there) of *K. usingeri*, there are "spots" on the membrane that could be interpreted as microtrichia. However, such a pattern with microtrichia absent is also characteristic of the Steingeliidae. The halteres are very narrow and slightly S-shaped, as in Ortheziidae (Koteja 1986).

The structure of the penial sheath in *Puto* is characterized by its apical hook-like extension, a feature unique in scale insects so far (Reyne 1954). Yet the same hook or thorn occurs in *K. usingeri.* However, the aedaegus in some species of *Puto* is bifurcate apically but is acute in *K. usingeri.*

Owing to some deformation of the abdomen it is difficult to comment about the four conspicuous waxy tails in *K. usingeri.* They do not correspond with the dorsal glassy straight waxy tubes forming a tuft characteristic of the Ortheziidae, Matsucoccidae, Margarodidae and some other archeococcids (well preserved in amber inclusions and rock impressions), neither with the lateral paired waxy rods in the neococcids. In the latter, the rods arise from a pocket of the wall that produces the rods and are supported by two or more long setae inserted at the bottom of the pouch. Two pairs of rods, on two terminal abdominal segments, are produced in some Phenacoccinae (Pseudococcidae) and a species from New Jersey amber (Koteja 2000), one pair in all other neococcids. Among archeococcids, one pair of tail organs has been described in the Steingeliidae and Phenacoleachiidae (for more details, see Koteja 1996). In *K. usingeri*, the four tails arise dorsally from one (the last) segment and are "soft" and flexible; they have been bent forward in the resin. Each of the tail filaments seems to have been produced by a single multilocular pore or tube (see description of species). They must be considered in the scale insects as unique tail devices which possibly developed through a modification of the archeococcid waxy tuft.

Most important in this discussion is the structure of the head. Advanced neococcid males bear four simple (unicorneal) eyes: one dorsal and one ventral pair. Some neococcids have more than two pairs of eyes (Putoidae, Kermesidae, some Coccidae), the dorsal and ventral eyes being the largest. Archeococcids bear, as a rule, compound eyes, but some of them have also simple eyes (perhaps 5 to 8 pairs) forming a circle or lateral rows, but never two pairs as the neococcids. It is obvious that simple eyes are the result of the degeneration of compound eyes, and that a circle or rows of simple eyes is an intermediate degenerative stage with eventual reductions resulting in two pairs of disintegrated ommatidia only. It is also evident that this process of degeneration and reduction occurred many times in various groups. For instance, some Coccidae have several pairs of eyes, others only two pairs which means that further reduction occurred within this family (Giliomee 1967). The Kermesidae bear several pairs of simple eyes, but their close relatives, the Eriococcidae, possess only two pairs which indicates that the eriococcid-kermesid ancestor had many eyes, and that reduction of their number occurred in the eriococcid branch, but not in the kermesid clade (Afifi 1968, Koteja and Zak-Ogaza 1972).

Among the archeococcids, reduction of eyes occurred in the following groups: Pityococcidae, Steingeliidae, Phenacoleachiidae (all extant), Electrococcidae and at least three other Cretaceous groups (Koteja, unpublished). With the degeneration of compound eyes and reduction of the number of ommatidia the head capsule and especially the ocular sclerites undergo significant structural changes which are more striking than the reduction of the number of ommatidia. Unfortunately, it is impossible to examine all the details of the head structure in fossils. In general, the head in *K. usingeri* is definitely different from that in the Putoidae, Kermesidae and Coccidae, but shows some similarity with the head of the above mentioned archeococcids. In all of them, the ocular sclerites are narrow and small compared with the large and projecting ommatidia which, in lateral view, form oblique rows. However, considering other features, it must be assumed that the reduction of eyes to simple ommatidia occurred independently in various archeococcids.

In conclusion, the Kukaspididae are archeococcids that developed many specialized and some unique features and at this time it is not possible to affiliate them with any fossil or extant group.

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